UAV-captured aerial image of lava flow at the Kīlauea volcano in Hawaii

TROUBLE IN PARADISE

UAVS HAVE BEEN USED TO MAP VOLCANOES, BUT THEY WERE FIRST USED OFFICIALLY TO AID DISASTER RESPONSE DURING THE ERUPTION OF THE KÌLAUEA VOLCANO IN HAWAII IN 2018. **ANDREA MASSEY** EXPLAINS HOW

Collapsing the earth under its summit and sending fountains of lava into surrounding communities, the months-long eruption of the Kīlauea volcano in 2018 shocked geologists. It made history as the volcano's most destructive eruption, destroying 700 homes. The event also gave rise to new firsts in technology applications, including a UAV strike team, and the volcano became the most monitored and scientifically understood in history.

A five-person team of highly trained volunteers from the Center for Robot-Assisted Search and Rescue (CRASAR) deployed to Kīlauea a few days after the eruption. They brought a fleet of small UAVs or 'disaster robots' to assist in rescue operations.

Natural disasters, from storms and floods to volcanoes and fires, present dangerous and life-threatening scenarios to first responders. Yet, disaster robots can go where people or emergency response dogs can't, thus minimising risk to life. This also freed other UAV resources to focus on geological observations during those crucial first days.

Justin Adams, the president of CRASAR, describes their experience vividly. "It was unique. I've never dealt with lava before. None of us have. We've dealt with mudslides, and we tried to compare it to mudslides. But just the colour of the lava, the sparkling of it burning up the vegetation and trees, looked like blood flowing down the side of the mountain. It looked like arteries because of the way it was pulsing."

Ground truth by UAV

Over six days, from 14 May to 19 May, CRASAR flew 44 UAV flights, 16 of which were at night. Manned aircraft such as helicopters weren't permitted to fly at night, so night UAV missions were invaluable. The crew staged UAV flights from restricted-access roads near the volcano, driving vehicles through evacuation zones and moving locations often to follow and map lava flows.

The UAVs were outfitted with XT2 thermal sensors, which retrieved RGB data in addition to thermal data, and each of those datasets was geotagged. With the UAVs, they identified a new fissure – Fissure 8, which was one of the most active for several months – mapped the lava fronts using thermal cameras, and provided data to the United States Geological Service (USGS) to help determine the speed of lava flow.

To capture the data, a UAV would hover above the front edge of a lava flow, take an image straight down, and note the GPS coordinate of that image. Several minutes

The CRASAR team stages a drone flight mission from a road near the eruption

later, the UAV would follow the leading edge of the flow to its new location and repeat the procedure. This was a much safer manoeuvre than previous methods, according to Adams.

"They had been gathering data by a person getting close to the lava, taking a GPS coordinate, waiting, and trying to walk down in front of the lava flow to take another GPS coordinate," he says.

During the day, UAVs mapped fissures and measured dangerous sulphur dioxide emissions, reducing the number of costly helicopter flights needed. In one mission, emergency personnel received an alert that someone might be in danger in an isolated house. One of CRASAR's UAVs quickly deployed to verify. In this process known as 'ground truthing', emergency responders validate the accuracy of incoming information to help plan response. The team acted as an on-demand strike force, responding to citizen reports and verifying air quality and lava flow.

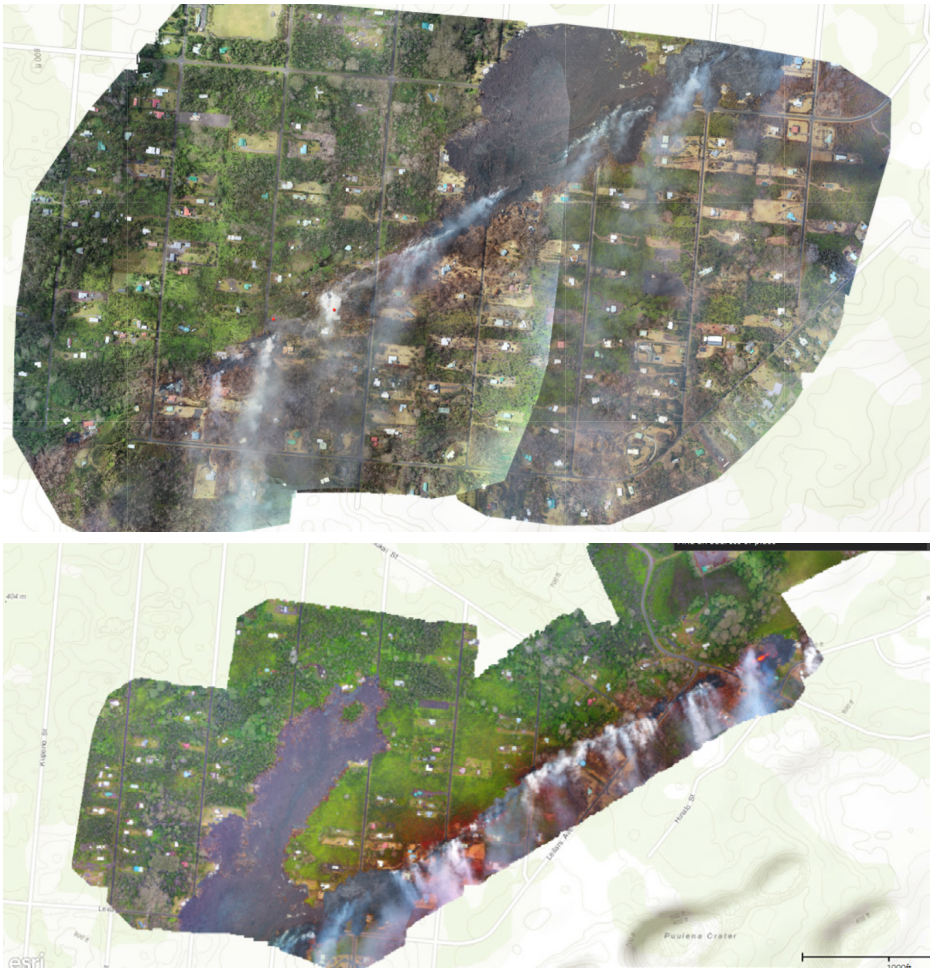
Automating response

Throughout its missions, CRASAR visualised imagery and information in real time using Esri's Drone2Map for ArcGIS. They also used Hangar Technology's UAV Robots-as-a-System imagery collection platform to take panoramic aerial photos automatically, instead of manually, expediting situational awareness.

Drone2Map transforms high-resolution UAV imagery into ready-to-use aerial data, bringing point clouds, mosaic datasets, 3D meshes, and orthomosaics directly into ArcGIS in near real-time. This enables users to instantly produce new observations, as well as store UAV data for later use. By automating the process of piloting UAVs, Hangar's platform has freed UAVs from human error, and eliminated much of the uncertainty and unpredictability of visual data capture.

The UAVs have an autonomous flight program and it builds a 360º flight. After being programmed with a location to fly to, it climbs to whatever altitude it's commanded to ascend to. Aerodynamically unconstrained from 300m and below, the UAV would take different flights from 120m to 275m, and then take 24 pictures in a series. The images were then uploaded automatically to the server, after which it would take about 15 minutes to process directly to the web interface. Once that data was in the cloud, anyone with access to the web portal could see the fully georeferenced dataset that had been captured.

When one of the autonomous UAVs repeatedly flies the same path with high accuracy, it offers a layer of precision spatial data that can then be integrated into Drone2Map for analysis. Remote GeoSystems' LineVision software could then be used to view and analyse the video within the GIS. Meanwhile, DJI's XT2 thermal sensor provided UAV-based air-quality monitoring.



Orthomosaic map made by stitching together UAV images, georeferencing, and overlaying on a basemap

The future

The work of UAVs in general at Kīlauea continued with the University of Hawaii at Hilo performing daily monitoring of the eruption. The UAVs provided a reliable stream of imagery helpful in communicating with the public.

"The visual data UAVs collect is very useful in helping show the people why they've been evacuated from certain areas," says Christian Wong, executive director, Hawaii Science and Technology Museum. "Once [residents] see the devastation and damage, they understand why they cannot be let back to their homes."

The CRASAR team's work was a success, reducing cost and risk to human life. They helped increase situational awareness for responders, government agencies, and the public. The team hopes this will build support for future use of robots and UAVs in disaster response and public safety. Emergency responders and scientists can now fly UAVs above a volcanic eruption for a safer way to observe and measure events..

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